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PROBLEM-SOLVING OR PRACTICE IN THINKING. IV¹

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Synopsis of this series of articles.—The three preceding articles contained (I) a discussion of “problems of everyday life”; (II) four “actual lessons” from the University of Chicago Elementary School illustrating practice in problem-solving from the kindergarten through the upper grades; and (III) a discussion of “how skilful problem-solvers think” as illustrated by Whewell’s description of the methods of thinking used by great scientists. The present article will continue this phase of the discussion and conclude the series with Section IV on “rules for practicing pupils in problem-solving.”

III. HOW SKILFUL PROBLEM-SOLVERS THINK (*Concluded*)

Dewey’s notable account of “how we think.”—Professor John Dewey is himself one of America’s greatest thinkers and is at the same time a trained psychologist who has specialized in the study of thinking processes. Consequently, his book *How We Think* (1910) deserves very special study. It should be read carefully time and again in order to grasp its detailed meanings. I have known a number of students, and even writers upon education, who have studied the book superficially and, as a consequence, failed to grasp some of its most significant points. Some of his most fundamental ideas, for our purposes, are contained in the three following paragraphs. The headlines are not in the original, and the paragraphing is slightly altered.

Origin in some perplexity.—We may recapitulate by saying that the origin of thinking is some perplexity, confusion, or doubt. Thinking is not a case of spontaneous combustion; it does not occur just on “general principles.” There is something specific which occasions and evokes it. General appeals to a child (or to a grown-up) to think irrespective of the existence in his own experience of some difficulty that troubles him and disturbs his equilibrium, are as futile as advice to lift himself by his boot-straps.

Form a tentative plan based on analogous past experience and prior knowledge.—Given a difficulty, the next step is suggestion of some way out—

¹ This is the last of a series of four articles on this topic. Reprints of the series may be purchased from the Department of Education, University of Chicago, for 40 cents each, postpaid; in lots of 25 or more, 35 cents each.

the formation of some tentative plan or project, the entertaining of some theory which will account for the peculiarities in question, the consideration of some solution for the problem. The data at hand cannot supply the solution; they can only suggest it. What, then, are the sources of the suggestion? Clearly past experience and prior knowledge. If the person has had some acquaintance with similar situations, if he has dealt with material of the same sort before, suggestions more or less apt and helpful are likely to arise. But unless there has been experience in some degree analogous, which may now be represented in imagination, confusion remains mere confusion. There is nothing upon which to draw in order to clarify it. Even when a child (or a grown-up) has a problem, to urge him to think when he has no prior experiences involving some of the same conditions is wholly futile.

Plan not accepted until carefully examined and criticized.—If the suggestion that occurs is at once accepted, we have uncritical thinking, the minimum of reflection. To turn the thing over in mind, to reflect, means to hunt for additional evidence, for new data, that will develop the suggestion and will either, as we say, bear it out or else make obvious its absurdity and irrelevance. Given a genuine difficulty and a reasonable amount of analogous experience to draw upon, the difference, *par excellence*, between good and bad thinking is found at this point. The easiest way is to accept any suggestion that seems plausible and thereby bring to an end the condition of mental uneasiness. Reflective thinking is always more or less troublesome, because it involves overcoming the inertia that inclines one to accept suggestions at their face value; it involves willingness to endure a condition of mental unrest. . . . Reflective thinking, in short, means judgment suspended during further inquiry, and suspense is likely to be somewhat painful. . . . The most important factor in the training of good mental habits consists in acquiring the attitude of suspended conclusion and in mastering the various methods of searching for new materials to corroborate or to refute the first suggestions that occur. To maintain the state of doubt and to carry on systematic and protracted inquiry—these are the essentials of thinking.¹

Dewey's text; state of doubt plus systematic and protracted inquiry.—In general, this quotation from Dewey gives us the same notions of careful inquiry that we derived from the accounts of Kepler's thinking, namely (1) prolonged careful search for suggested solutions, (2) careful open-minded evaluation and testing of each suggestion or plan, (3) suspended judgment, patience to wait until the true solution has been discovered and verified. Since the language of Dewey's paragraphs varies from Whewell's account of Kepler, we can pick up from Dewey some excellent additional phrases to use in our thinking about training in problem-solving.

¹ John Dewey, *How We Think*, pp. 12-13. Boston: D. C. Heath & Co., 1910.

Perhaps the best of these are contained in the final sentence, "To maintain the state of doubt and to carry on systematic and protracted inquiry—these are the essentials of thinking."

With such an understanding of the nature of skilful problem-solving as we can derive from these accounts by Whewell and Dewey, and from the accounts of actual problem-solving lessons given earlier in the discussion, we can now proceed to summarize our ideas of how to train pupils in problem-solving.

IV. RULES FOR PRACTICING PUPILS IN REFLECTIVE PROBLEM-SOLVING

Assume suitable problem, adequate experience, and interesting dilemma.—At the outset of this section, we may assume (1) that a problem adapted to the pupils' maturity and experience is to be solved; (2) that the pupils have analogous previous experience and related information needed for the solution or they know how to proceed to get this information; and (3) that an interesting dilemma has been created. In other words, we shall assume that a suitable problem for solution has already arisen from some puzzling situation and that the pupils are interested in solving it.

Interest in problem increased by competition.—Their interest may arise from the mere instinctive interest in thinking which we described early in the articles and which leads many adults and children to enjoy playful puzzling about all sorts of perplexing, strange, unexpected, or disconcerting occurrences. This instinctive interest easily maintains itself and is greatly aided by the instinctive interest in *competition*. Pupils compete to make appropriate suggestions, to criticize the suggestions of others, and in general to "win out" personally in achieving the solutions of the major problem and its many subdivisions.

Teacher's threefold task.—With such an interesting situation created, the teacher's task becomes one of (1) guiding the thinking of the pupils; (2) aiding them when confronted by difficulties that are beyond their powers or which they would waste their time in solving; and (3) eventually making them aware of what good thinking is, so that they may consciously strive for it during their thinking, just as they strive to improve their handwriting or their reading.

Thorndike's parallel for guiding thinking. Finding the road to grandpa's.—The general nature of a teacher's activity in assisting pupils in problem-solving is cleverly suggested by Thorndike when he compares it to assisting a child to discover the road to grandpa's house instead of merely taking him by the hand and leading him there. In such guidance, Thorndike says:

You must make sure (1) that the youngster knows what place he is to try to reach and (2) keeps it in mind. (3) He must also at least know that to get to a place [or to solve a problem] you must keep going and not lie down and go to sleep; (4) he must have some knowledge of the direction in which the house lies and of the roads and woods and valley in the neighborhood.

He starts off correctly and at a cross road [or alternative in the problem] turns to the left.

"What did you do that for, John?" [asks the guide]. "I don't know."
"Where are you going?" "To grandpa's." "Where does that road go?"
"To the schoolhouse." "Is that on the way to grandpa's?" "I don't know."
"What comes after the schoolhouse if you go down this road?" "The church."
"How long does it take to go from grandpa's to the church?" "O, a long time."
"Is grandpa's near the church?" "No. It is a long way." "This road goes to the church. Is it a good way to go to grandpa's?"

If your boy is bright enough, he now turns to the right, but soon comes to the end of the road [or the suggestion that is being followed in trying to solve the problem]. "Where do I go now?" says he. "Where do you think?" "I think we go through that field." "Well, try it and see."

You rapidly approach a pond [or discouraging difficulty in the problem] and the boy sits down and cries. "I can't find the way to grandpa's." "What's the trouble?" "You can't get around this pond, it's all swampy." "Do you have to go around it?" "Yes. Grandpa's is up there and you have to go around the pond." "Go and look at the pond [or examine the difficulty] and see if you can find something that will help you to get to grandpa's."

And so on with constant stimulation to the examination of each situation confronted, and with the selection and rejection of ways in the light of knowledge of their consequences, until grandpa's house is reached, or until the problem is solved.¹

Five specific rules for conducting problem-solving lessons.—The general impression of methods of guiding pupils in problem-solving which we derive from this little imaginary story may now be formulated into the specific rules given below. These rules also summarize and definitize most of the points of technique brought out

¹ E. L. Thorndike, *Principles of Teaching*, pp. 150-51. New York: A. G. Seiler, 1905.

in the sample lessons in Section II, plus the characteristics of skilful problem-solving described in Section III of the discussion.

1. *Define problem.*—Aid the pupils to define the problem clearly. This rule is important in good individual thinking, but is particularly important in group thinking. For example, while writing the preceding paragraphs, I was disturbed by two well-intentioned intelligent persons who were arguing most vigorously, but quite uselessly, because they were talking at “cross purposes.” I said to them, “Do you folks realize that you are not talking about the same thing? One of you misunderstood what the other asserted a moment ago.” Upon a little inquiry, my statement proved to be true, the parties found themselves in perfect agreement, and I could proceed with my work undisturbed. In college debates, we find some of our best examples of care in defining the question or problem for a group discussion. Many hours or days or weeks may be spent in getting the problem clearly in mind and giving it such a satisfactory wording that definite profitable debating may proceed. In our seventh-grade lesson on sugar production, we noticed that Miss Parker had the class formulate a definite proposition as the basis of the discussion and then she wrote it on the board, so that all got it clearly in mind. In our fifth-grade lesson on London, we found she had written eight carefully phrased problems on the board as the basis of the lesson, and that each one that needed further defining received it in the discussion.

2. *Keep problem in mind.*—Help the pupils to keep the problem clearly in mind. This rule is necessitated by the large waste of time and energy that results from being side-tracked, even after the problem has been clearly defined. “Scatter-brained thinking” is a term to designate thinking that does not hold definitely to the question. In deliberative bodies that have good rules of procedure, one important duty of the presiding officer is to hold the discussion to the question before the house, and to rule out digressions. In the lessons in Section II, we saw frequent occasions for this procedure; e.g., in the second-grade lesson a child began to talk about dressing a French doll instead of an Arab doll; in the seventh-grade sugar-production lesson, the teacher had difficulty in restraining a boy from discussing “profitable” instead of “possible.” Through

such guidance the pupils learn that "keeping to the question" is a characteristic of good thinking. They come to realize this from repeated suggestions from the teacher, such as Miss Parker's remark when the class was discussing the relation of London and the Thames, "It is not a good answer unless it shows how London is *related* to the Thames."

3. *Stimulate suggestions. Analysis, recall, guesses.*—Aid the pupils to make suggestions by getting them (a) to analyze the problematic situation into parts or elements, each of which may suggest a solution; (b) to recall previously known similar cases, or, as in arithmetic and geography, general rules that may apply; (c) to formulate from vague guesses definite hypotheses or tentative plans.

Control of one's own associations is difficult. Galton.—These rules are among the most difficult to explain and apply, because fertility in suggesting is probably less easily controlled by a thinker, and consequently by a pupil, than any other phase of thinking. This fact is picturesquely described by the eminent English scientist, Sir Francis Galton, a member of the noted Darwin family and well known as founder of the eugenics movement. He compares his mind, when solving a problem, to two rooms, one an "audience chamber" in which the main ideas of the moment have the floor, and the other an "antechamber" in which there is a throng of those ideas that are vaguely present in his mind at the time. "Successful progress of thought," he says, "seems to depend, first, on a large attendance in the antechamber. . . . [This] thronging of the antechamber is, I am convinced, altogether beyond my control; if the ideas do not appear, I cannot create them nor compel them to come."

Maneuvers for attracting appropriate suggestions.—While Galton's statement that we cannot compel appropriate ideas or suggestions to appear is true, yet we can go through certain maneuvers that will tend to attract or arouse or recall them.

a) *Analytic attention focuses upon one element at a time.*—One such maneuver is to proceed to focus our attention on one part of the problematic situation at a time. For example, in the sugar-production problem, the class divided the issue into cane production and sugar-beet production and then focused their attention on the

former. Holding, then, to the problem of growing more cane, a host of issues were suggested, such as number of growing days, competition with Cuban labor, etc. Similarly, in fitting the front to the cardboard store in the kindergarten, attention was focused for a time on the *width*, and suggestions "sprouted" for determining this, for marking straight lines by folding, etc. In studying the growth of London, the fifth-grade class was found breaking the issues up into where the docks would be located, where the warehouses would be located, and similar questions with factories, homes for workers, fine residence districts, etc.

Each focused element brings its suggestions. By dividing we conquer.—Thus by actively dividing a problematic situation into certain of its elements, and purposely attending to one of these for the time being and neglecting others, we open up many sources of suggestion which might not have opened so soon had we merely passively regarded the large problem and waited for something to happen. The teacher can often help a class over an apparently insurmountable difficulty in their problem by merely suggesting that they devote their attention to a certain phase of it which she mentions, or by naming a number of alternative phases, one of which they take up and examine.¹

b) Recalling similar cases and rules that apply. Degrees of assistance.—Recalling previously known similar cases or general rules that may apply is particularly easy in arithmetic or geography where the material is systematically organized. For example, when asked what conditions must be studied in planning to grow sugar cane, a pupil could say to himself, "Let me see, what conditions

¹ The proper location of *analysis* as a method of control in problem-solving has puzzled me more than any feature of this section. Its value is quite obvious and has been especially emphasized by William James. (See his *Principles of Psychology*, II, 339-40.) Whether (a) to locate such purposeful analytic concentration of attention under rule 3, as one means of controlling suggestions, or (b) to give it an independent place, has been my dilemma. In placing it as a control device under the more general heading of stimulating suggestions, I have been guided largely by my own experience in solving geometry exercises. In this case, it seems to me, I commonly focus my attention on a certain angle or a certain line *in hopes* that it will suggest some further possibilities of procedure. By thus controlling our attention, we discount somewhat Galton's point about being unable to control the thronging of the ante-chamber; because the aspect attended to, will, figuratively speaking, invite its own crowd to the room.

did we take up for growing cotton and corn?" Similarly, if the fifth-grade pupils who had studied London should later study the growth of New Orleans, they might say, "Let's see, what were some of the factors we brought out in the case of London?" In the case of mathematics, the procedure of recalling the desired rule is often aided mechanically by turning the pages until an appropriate one appears. The practice of looking up some related discussion in a book is a device that many students and scientists use to start suggestions that may help solve the problem. Such systematic recall may be aided by the teacher in various degrees. For example, in the kindergarten, the teacher may make a very general suggestion, such as, "How can we find out how many hinges a door should have?" or the more definite suggestion, "What shall we look at to determine how many hinges a door should have?" or the very specific suggestion, "Look at the doors in this room to see how many hinges we ought to have on our door."

c) *Guessing. Leaps in the dark definitized as hypotheses.*—Guessing and formulating definite hypotheses from the more vague guesses are processes that we found especially emphasized in Whewell's description of scientific procedure. Recently I heard a chemist say that for two years he had tried to obtain a certain reaction in his laboratory without success. He had tried a score of devices in vain. One day, while walking across the campus, it occurred to him to try out a procedure that he had frequently thought of but had always mentally discarded because it seemed too foolish. He went to his laboratory, tried it, and it proved to be the long-sought method. Providing that pupils are seriously concerned with their problems and have a fund of related experiences, such courageous guessing, leaps into mental darkness, should be encouraged. In class discussions, as many such pertinent guesses are rapidly made, they may be rapidly noted on the blackboard, then the more probable ones taken up and definitely formulated and examined to determine their value.¹

¹ In high-grade scientific investigations, this "*method of multiple hypotheses*" is highly esteemed. Its general character is brought out in the following quotation from Dewey (*op. cit.*, p. 75): "Suggestion is the very heart of inference; it involves going from what is present to something absent. Hence it is more or less speculative, adventurous. Since inference goes beyond what is actually present, it involves a

4. *Evaluate suggestions. Open-mindedness; criticism; verification.*—Encourage pupils to evaluate suggestions carefully by getting them (a) to “maintain the state of doubt,” i.e., to delay their final conclusion and to remain open-minded until the matter is finally proved; (b) to criticize thoroughly all suggestions, i.e., to anticipate mentally objections that might be made to them or consequences that might follow; (c) to verify suggestions and conclusions by reference to facts as revealed around them or in miniature experiments or in standard scientific treatises. The subdivisions of this rule we found especially emphasized in the last paragraph from Dewey at the beginning of this article.

a) *Maintain state of doubt. Avoid pugnacious stubborn argument.*—The rule about suspending judgment defines the general spirit that should prevail in the class and in the mind of each inquirer. It raises an interesting question concerning the amount of argument that should be permitted in classes. While argument may be very stimulating to thought and interest, the spirit of argument is often just the opposite of the spirit of open-minded inquiry. Argument is often closely akin to fighting; the more your opponent hits you, the harder, and frequently the more blindly, you hit back. I have seen pugnacious, argumentative boys in upper-grade classes, who cared nothing about careful evaluation of their suggestions, but were merely concerned to maintain these at all costs. Where such a spirit is allowed to become strong in a class, the opportunities for training in impartial, open-minded, scientific inquiry are jeopardized. The teacher should be herself a model of impartiality in inquiry; she should make this the dominant spirit of the teaching, and should train each pupil to esteem fair-minded search after truth as a high ideal and a desirable personal attribute.

b) *Acquire attitude of criticizing suggestions. Anticipate objections and consequences.*—Teaching students to criticize, to anticipate

leap, a jump, the propriety of which cannot be absolutely warranted in advance, no matter what precautions be taken. Synonyms for this are *supposition, conjecture, guess, hypothesis*, and (in elaborate cases) *theory*. Since suspended belief, or the postponement of a final conclusion pending further evidence, depends partly upon the presence of rival conjectures as to the best course to pursue or the probable explanation to favor, *cultivation of a variety of alternative suggestions* is an important factor in good thinking.”

mentally, possible objections to and consequences of a suggestion or scheme, appears as the notable feature of the work of certain teachers. The actual calling to mind of specific criticisms is a matter of fertility of suggestion, but the general attitude of trying out mentally each suggestion before adopting it can be maintained even in cases where one may be unsuccessful in calling to mind specific objections and consequences.

c) *Verify by known conditions, miniature experiments, and scientific treatises.*—Closely related to this mental trying-out is the verification of suggestions and conclusions by reference to known facts as revealed around us or in standard scientific treatises. For example, in the kindergarten construction lesson, a child who wanted to have only one hinge on a door should have felt that this was probably undesirable after examining all doors and finding none with one hinge. Of course, he might have tried one hinge and found that it wouldn't work. Wherever possible, however, in social life, people try to avoid an expensive, poorly conceived experiment if it is possible to determine in advance, from facts already known, that it will be a failure. Often scientific experimentation in a laboratory consists in carrying on some process in miniature, or on a small scale, to see if it will work. In primary construction classes, a similar practice is often followed by letting one child try out a suggestion before all adopt it. As further examples of the process of verifying suggestions, we found the pupils in the Arab-doll lesson referring to standard pictures of Arab life to verify some of their plans for the Arab costumes; and in the sugar-production lesson, we found the teacher provided with a report of the Department of Agriculture and a special scientific treatise on sugar, to use in checking up the conclusions that the pupils reached concerning the possibility of increased sugar-cane production.

5. *Keep discussion organized. Outlines, graphs, summaries.*—Help pupils to keep the discussion organized by proceeding (a) to build an outline of the main ideas on the board as they appear in the discussion; (b) to use diagrams and graphs for condensing fundamental facts and relations into a simple picture; (c) to take stock from time to time by summarizing the ground covered and

the next steps to be taken; (d) to formulate from time to time, as definite propositions, the net outcome of the discussion.

These last rules are very objective and easy to understand and illustrate. We found an example of building an outline on the blackboard in the sugar-production lesson; of the effective use of a graph to summarize the sugar situation in the same lesson and of a diagram to clarify and summarize the development of London in the fifth-grade lesson. We found the second-grade class taking stock of their plans for the Arab costume, and the fifth-grade class summarizing their facts about the relation of London and the Thames. The concise formulation of definite propositions containing the net outcome of the discussion occurred several times in the sugar-production and London lessons.

Summary of rules for conducting problem-solving lessons.—The five major rules with their subdivisions presented above describe many, if not most, of the special practices that should characterize a teacher's guidance of pupils during a problem-solving lesson. They may be summarized in more concise form in the following statement:

To stimulate and assist pupils in reflective problem-solving, the teacher should

1. Get them to define the problem clearly
2. Aid them to keep the problem in mind
3. Get them to make many suggestions by encouraging them
 - a) To analyze the situation into parts
 - b) To recall previously known similar cases and general rules that apply
 - c) To guess courageously and formulate guesses clearly
4. Get them to evaluate each suggestion carefully by encouraging them
 - a) To maintain a state of doubt or suspended conclusion
 - b) To criticize the suggestion by anticipating objections and consequences
 - c) To verify conclusions by appeal to known facts, miniature experiments, and scientific treatises
5. Get them to organize the material by proceeding
 - a) To build an outline on the board
 - b) To use diagrams and graphs
 - c) To take stock from time to time
 - d) To formulate concise statements of the net outcome of the discussion

Primary education no longer mere arbitrary memorization.—The type of training summarized in the foregoing rules differs greatly

from that which prevailed in many schools a generation ago and which was seriously advocated by a prominent American writer on education as late as 1904, when he said the age before twelve is the age for "arbitrary memorization, drill and habituation, with little appeal to children's interest or understanding." Such a theory was based on the assumption that little children cannot succeed in reflective problem-solving. It requires little observation to show that little children solve their problems by the same processes of making and evaluating suggestions that ordinary adults use.¹ The great growth that may be made by pupils in reflective ability, through providing opportunities from the kindergarten up, appears when one contrasts the recitations observed in the upper grades of an old-fashioned memorizing school with those in the same grades of a progressive school in which problem-solving methods prevail in construction, expression, history, geography, and other subjects. In such a progressive school, pupils in the upper grades are prepared to attack such a technical problem as increasing American sugar production in the effective manner described in these articles, and with a mastery of technical devices of research and inquiry not possessed by some educated adults.

Both routine drill and problem-solving have a place.—Let us hasten to say, however, that this emphasis on problem-solving should not lead to a neglect of routine drill of the type that prevails in the modern scientific teaching of handwriting, spelling, reading, and arithmetic. The necessity of such drill has been amply demonstrated in scientific investigations; and its presence in the school need not interfere at all with the adequate organization of problem-solving. Both may proceed in the same day without mutual interference, e.g., during the handwriting and spelling periods, the most intense, gameful, effective drills may be carried on, with little or no problem activity, while in some of the history and geography periods the most intense reflective problem-solving may prevail.

Give both habits and standards of good thinking.—Such training in problem-solving should not only give pupils greater skill in solving

¹ For experimental evidence on this point see F. N. Freeman's *How Children Learn* (Houghton Mifflin Co., 1917), chap. xi on "Problem-Solving or Thinking," and S. C. Parker's *Methods of Teaching in High Schools* (Ginn & Co., 1915), pp. 326-32.

problems in special lines, such as construction or geography, but it should also make them eventually clearly aware of what the attributes of good thinking are. For example, we suggested that pupils should come to esteem open-minded, impartial, suspended judgment as an ideal, as a personal attribute which they desire to possess. Similarly, we suggested that they learn to be on their guard to hold to the question under discussion. Again, we might have noted under rule 5 that the pupil should learn to appreciate the value of outlines, graphs, diagrams, and summaries as aids to effective thinking, and consciously strive to use these when appropriate occasions offer.

Cultivating originality. What does it mean?—The foregoing discussion helps us to define clearly what we mean by “cultivating originality,” a phrase that is extensively but often vaguely used in many educational discussions. Very commonly such discussions consist merely of vicious attacks upon drill, routine, memorizing, and imitation, with strenuous appeals to rid the schools of these and to substitute, instead, training in originality and initiative. We have called attention to the fallacy of this position in the preceding paragraphs. So confused, however, is the issue concerning the proper balancing of reflective, original thinking, on the one hand, and routine drill and imitation on the other, that we shall note a few more points concerning it.

Capacity for original thinking is inborn, varies between individuals, and is often specialized.—In trying to make our discussion concrete, we may think of Edison, Darwin, Newton, and other great originators and inventors as typifying great capacity for original thinking. At the opposite extreme, we have the feeble-minded, many of whom, while able to learn such routine tasks as washing dishes or dusting, have little ability to solve problems. It is perfectly clear from scientific studies of geniuses and the feeble-minded, that the differences between them are due to inner characteristics of the individuals, usually inherited characteristics. These differences cannot be overcome by training. You cannot make an Edison out of a feeble-minded person. In the intermediate ranks, between the original geniuses and the feeble-minded, the capacity for original thinking is also determined by the individual's native endowment;

if he is well endowed by nature, he *may* become a skilled thinker; if he is poorly endowed, the best training will still leave him a poor thinker. Moreover, his capacity for original thinking may be specialized, e.g., a boy may prove quite ingenious in devising mechanical appliances, but fail in working original problems in mathematics. Similarly, a person may rank high in the capacity for original thinking in mathematics, but fail in making original compositions in music, or writing original poems, or devising original plots for novels. For our present purposes, it is sufficient if we can get the teacher to think of each pupil as possessing a certain amount of native capacity for original thinking. Her task is to cultivate each pupil's capacity quite specifically. If he is brilliantly original in geography, give him large opportunities; if he is rather stupid and unoriginal in geography, give him some small easy problems that will give practice for what little talent he possesses. In every case, treat each pupil sympathetically so as to develop such talents as he does possess for the good of himself and society.

The pupil must succeed in order to improve.—Such sympathetic treatment may be further justified by the scientific fact that, in any type of learning, a pupil learns through his successes. It is the successful performances, not the unsuccessful ones, that form the correct habits in solving problems and doing original thinking, just as in learning spelling or handwriting. A pupil who never succeeds in solving an original problem will not learn to solve original problems. Owing to the fact that problem-solving, as a rule, necessarily involves erroneous guesses and the testing of these, the teacher is confronted with a very delicate task in determining just how difficult the problems should be for each pupil, and just how much aid to give him in order that he may succeed and yet be required to do sufficient mental experimentation to secure the necessary practice.

Standardized graded problems needed.—Great help will be afforded in this dilemma when we have developed in each grade for each subject standardized, published, ready-made problems varying from the easy for the dull pupils up to those of sufficient difficulty to challenge the ability of the best thinkers in the class. We

noticed how Miss Parker was engaged in devising such problems with the necessary data for fifth-grade geography.¹

Vary recitations for the timid, the aggressive, the slow, the impulsive, etc.—In the problem-solving recitation, the teacher must provide for individual differences by calling on pupils according to their capacities and temperaments. For example, for the dull pupils, the pupils who have little native capacity, she will save the easiest questions, remembering that they need to succeed in order to profit. The slow but capable thinkers will be taken care of by slowing up the pace frequently for their especial benefit. The timid but capable thinker will be watched carefully and probably given at first easy questions that can be answered in a few words. As he acquires confidence from his successful answers to these, he may eventually lose his timidity in this particular class. The impulsive thinker who does not stop to evaluate his suggestion before popping it out will need to be retrained, possibly by promising to ignore him if he continues wildly to make suggestions, but to favor him after he has made a well-considered one. The argumentative quibbler will need his spirit changed by being made to realize that the class does not care for his pugnacious, stubborn adherence to a suggestion, but will welcome him if he really tries to aid in an impartial inquiry for the true solution.

Large project problems often overlook the timid and slow.—It is in problem-solving which centers in large projects that the teacher needs particularly to be self-possessed and resourceful in providing for individual differences. For example, one sixth-grade class spent twelve weeks on a project dealing with the topic "Ships and Shipbuilding."² In carrying out this project, the pupils undertook a variety of problems of an expressional character. In such teaching, the more capable pupils exhibit so much talent in planning and

¹ The publishing of carefully prepared printed problems with the data for their solution will greatly facilitate the adoption of problem-solving methods in geography and the social sciences, especially by busy or inexperienced teachers. For examples of such publications for college classes see the series of *Parallel Source Problems in History* published by Harpers, and my own *Exercises for Methods of Teaching in High Schools* published by Ginn.

² Edith Parker, "A Sixth-Grade English Unit," *Elementary School Journal*, XV (October, 1914), 82-90.

devising things to do that they are likely to monopolize the interest of the teacher, leaving little or nothing of a problem type for the slow or the timid pupils to concern themselves with. This fact led Miss Parker, who organized this twelve weeks' project, to emphasize the fact, as we noted above, that in many problem-solving lessons the slow pupils are left entirely out of the game.

Conclusion of articles on problem-solving.—We opened these articles with an account of the part played by problem-solving in social life. We found both practical and speculative problems interesting children and adults. We found problems of many types, such as mechanical, diplomatic, moral, aesthetic, mathematical, etc. In Section II, we presented in detail four actual lessons which gave us concrete pictures of the conversational reflective activity that prevails in skilfully conducted problem-solving discussion lessons. In Section III, we showed how great problem-solvers think. We found them making many suggestions, evaluating these carefully and discarding the erroneous ones, and maintaining an unbiased impartial attitude in their conclusions. From Sections II and III we derived a number of rules for training pupils in problem-solving which we presented in Section IV. We suggest that the reader learn the summary of these rules as given above, and then with concrete pictures of the actual lessons given in Section II, plan to undertake, at least occasionally, to conduct problem-solving lessons in her own teaching. We prophesy that if she is a good thinker herself, she will find great pleasure in trying to develop skill in this important type of artistic teaching.